



Validation of the Aura Microwave Limb Sounder Measurements of Nitrous Oxide

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FIRS, SLS, CWAS, LACE, MIPAS, ACE, Odin/SMR

Jet Propulsion Laboratory, California Institute of Technology

Aura Validation Meeting, Boulder
September 2006

Overview of the Aura MLS v2.10 N₂O data product

- ▶ MLS standard product N₂O is retrieved from observations of the limb emission at 652.7 GHz
- ▶ v2.10 N₂O retrievals have a useful range from 68 – 0.1 hPa
- ▶ Effects of clouds are negligible
- ▶ Profiles are retrieved on a pressure grid consisting of 6 levels per decade (spacing ~2.5 km) and 3 levels per decade for pressures < 0.1 hPa
- ▶ Vertical resolution (averaging kernel FWHM) is ~4 km in the mid-stratosphere
- ▶ Horizontal spacing of profiles is 1.5° great circle arc along the orbit track (~160 km, 24.6 s)
- ▶ A separate retrieval of N₂O from the 190 GHz radiometer is currently considered as a diagnostic product only

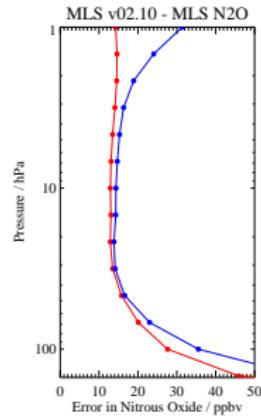
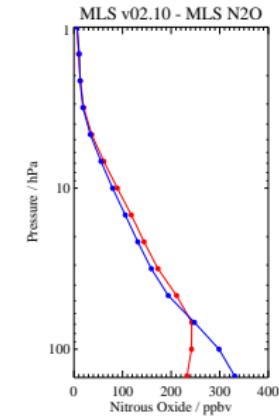
MLS N₂O Retrieval

- ▶ N₂O is retrieved in the ‘Core+R4B’ phase from the MLS R4 640 GHz bands
 - ▶ band 12: 25 channel filterbank (1300 MHz bandwidth, 6 MHz band center, 96 MHz band edge)
- ▶ SO₂ is also retrieved in the Core+R4B phase
- ▶ Contaminating emission is present due to O₃ (and excited states/isotopes), HNO₃, and H₂O in the UTLS. These species are constrained to the values obtained from previous retrieval phases

Improvements to the retrieval scheme for v2.10

- ▶ Updated spectroscopy for contaminating species (O₃, HNO₃)
- ▶ Employed more accurate full forward model for band 12
 - ▶ A linearized forward model was used for v1.51 based on pre-computed radiances and derivatives for climatological atmospheric states (altitude, latitude, month). The accuracy is limited by the extent of the departure of the true state from the a priori state (linearization point) and is generally poorer in the winter polar vortices.

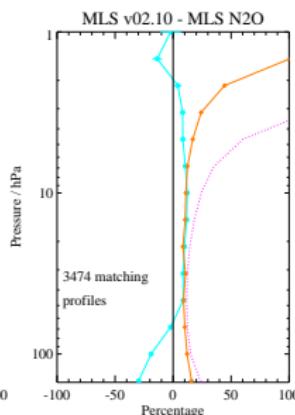
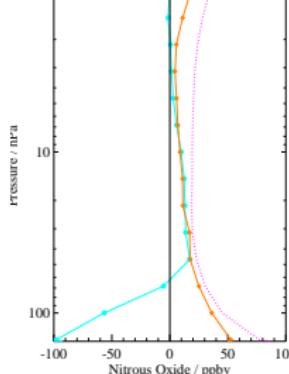
Comparison of MLS v2.10 N₂O with v1.51



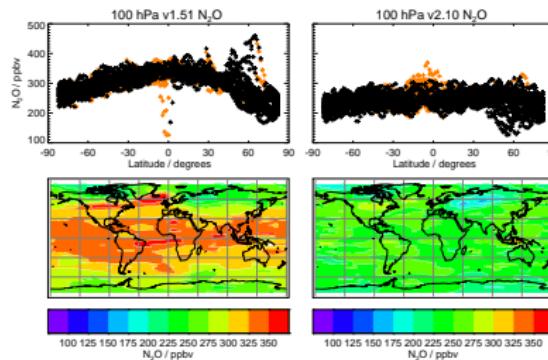
28 January 2005

- ▶ Upper panel: Global mean vertical profiles
 - ▶ MLS versions **v2.10** and **v1.51**
 - ▶ Left: Mean vmr profile
 - ▶ Right: RMS precision profile

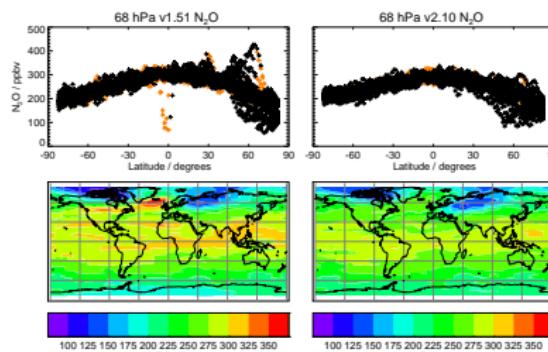
- ▶ Lower panel: Global mean difference vertical profiles
 - ▶ Left: Statistics of profile differences in vmr units
 - ▶ **Mean difference** (**v2.10 – v1.51**)
 - ▶ **RMS difference**
 - ▶ **Expected RMS difference**
 - ▶ Right: as Left except shown as a percentage



Anomalies in the N₂O Data Product



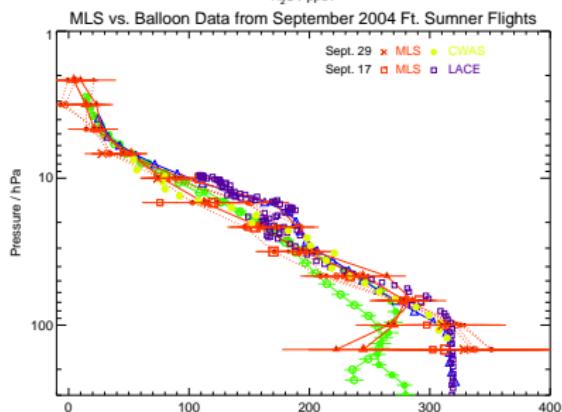
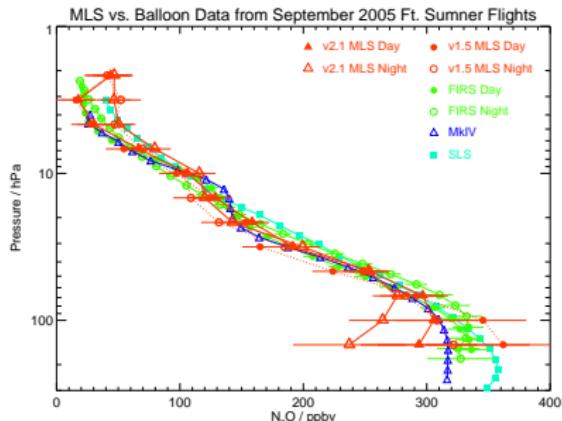
- ▶ Upper panel: 100 hPa N₂O
- ▶ Left: v1.51
 - ▶ Scatter plot: orange points indicate data marked by status/quality flags
 - ▶ Map: latitude – longitude distribution
- ▶ Right: as Left except for v2.10
- ▶ Lower panel: as Upper panel except for 68 hPa N₂O



Not all anomalous data points were detected by the status/quality flags in v1.51 (an off-line data mask is available)

v2.10 N₂O is clearly too low at 100 hPa, but at 68 hPa the artifacts due to poor convergence in v1.51 have been improved

Comparisons of MLS N₂O with Balloon Measurements



Single profile co-incident MLS retrievals
compared to Ft. Sumner Balloon
measurements

co-incidence selection: closest matching day
and night MLS profiles

MLS v1.51 dashed red line, circles
MLS v2.10 solid red line, triangles

Day: closed symbols
Night: open symbols

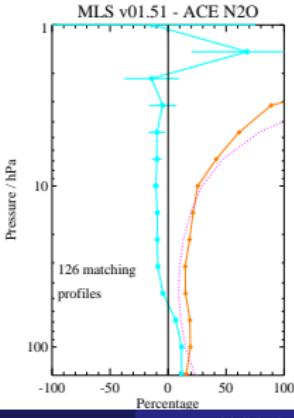
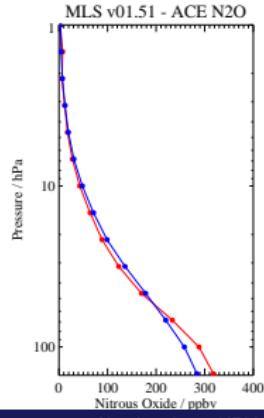
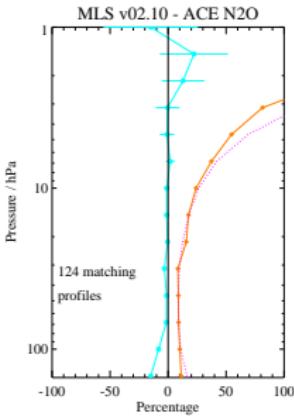
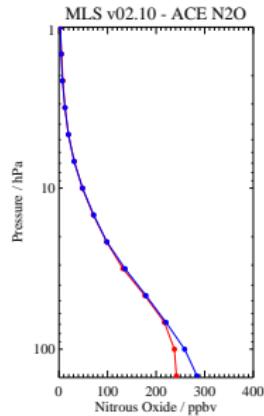
▶ Upper panel: September 2005

- ▶ 20–21 Sep: JPL MkIV, Far Infrared Spectrometer (**FIRS-2**), Submillimeterwave Limb Sounder (**SLS-2**)

▶ Lower panel: September 2004

- ▶ 17 Sep: Lightweight Airborne Chromatograph Experiment (**LACE**)
- ▶ 23–24 Sep: JPL MkIV, Far Infrared Spectrometer (**FIRS-2**)
- ▶ 29 Sep: Cryogenic Whole Air Sampler (**CWAS**)

Comparisons of MLS N₂O with ACE-FTS



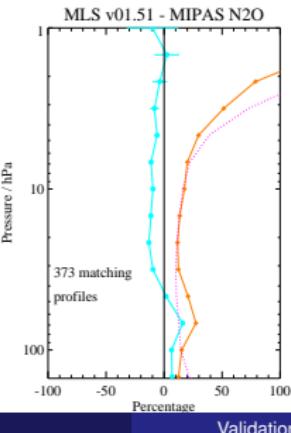
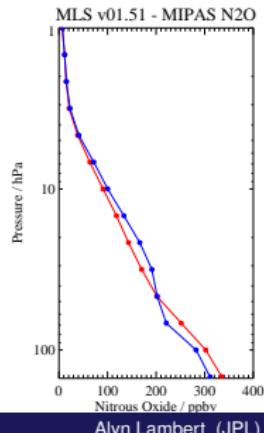
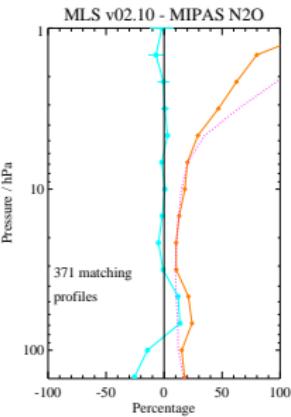
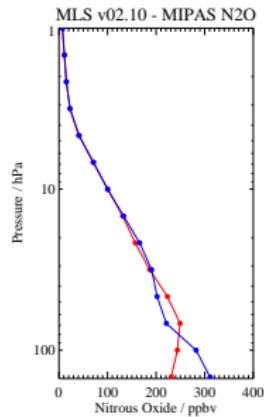
Atmospheric Chemistry Experiment Fourier Transform Spectrometer

17, 23, 24, 25, 29 Sep 2004; 3, 12, 29 Nov 2004; 27, 28 Jan 2005 2, 5 Feb 2005;
4 May 2005; 20, 21 Sep 2005; 22 Jan 2006; 20 Feb 2006

co-incidence window: 1° lat, 4° lon, 12^h time

- ▶ Upper panel: Global mean vertical profiles
 - ▶ MLS v2.10 and ACE v2.2
 - ▶ Left: Mean vmr profiles
 - ▶ Right: Statistics of profile % differences
 - ▶ Mean difference (MLS – ACE)
 - ▶ RMS difference
 - ▶ Expected RMS difference
- ▶ Lower panel: Global mean vertical profiles
 - ▶ as Upper panel except for MLS v1.51

Comparisons of MLS N₂O with MIPAS

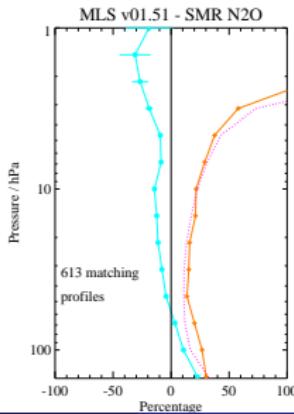
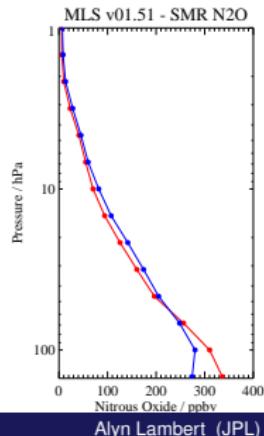
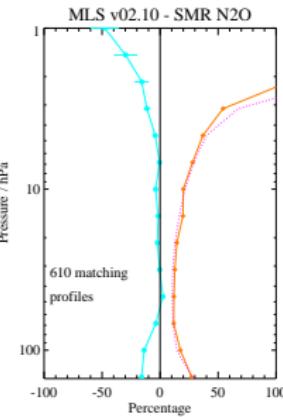
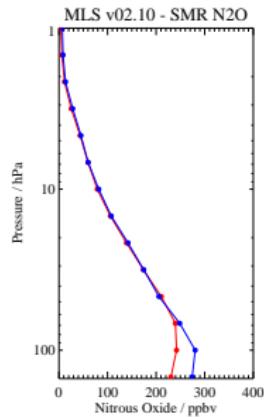


Michelson Interferometer for Passive Atmospheric Sounding

9 orbits on 28 January 2005
University of Oxford off-line retrievals
co-incidence window: 1° lat, 4° lon, 12^h time

- ▶ Upper panel: Global mean vertical profiles
 - ▶ MLS v2.10 and MIPAS
 - ▶ Left: Mean vmr profiles
 - ▶ Right: Statistics of profile % differences
 - ▶ Mean difference (MLS – MIPAS)
 - ▶ RMS difference
 - ▶ Expected RMS difference
- ▶ Lower panel: Global mean vertical profiles
 - ▶ as Upper panel except for MLS v1.51

Comparisons with Odin/SMR



Odin Sub-Millimetre Radiometer

24, 25 Sep 2004; 28 Jan 2005; 22 Jan 2006

co-incidence window: 1° lat, 4° lon, 12^h time

- ▶ Upper panel: Global mean vertical profiles
 - ▶ MLS v2.10 and Odin/SMR Chalmers v2
 - ▶ Left: Mean vmr profiles
 - ▶ Right: Statistics of profile % differences
 - ▶ Mean difference (MLS – SMR)
 - ▶ RMS difference
 - ▶ Expected RMS difference
- ▶ Lower panel: Global mean vertical profiles
 - ▶ as Upper panel except for MLS v1.51

Conclusions

- ▶ MLS v2.10 N₂O is ~10% larger than v1.51 in the mid-stratosphere
- ▶ The estimated precision of MLS v2.10 N₂O is 20 ppbv at 68 hPa and 15 ppbv for pressures 56–1 hPa
- ▶ In general the biases and rms scatter of MLS v2.10 N₂O against ACE, MIPAS and SMR are very good and show significant improvements over the MLS v1.51 data
- ▶ Problems with poor convergence have been reduced in the MLS v2.10 N₂O retrievals
- ▶ Further refinements of the MLS Level-2 N₂O data product will address the problem with the low values of N₂O at pressures \geq 100 hPa
- ▶ Release of the MLS v2.2 data products is planned for November 2006